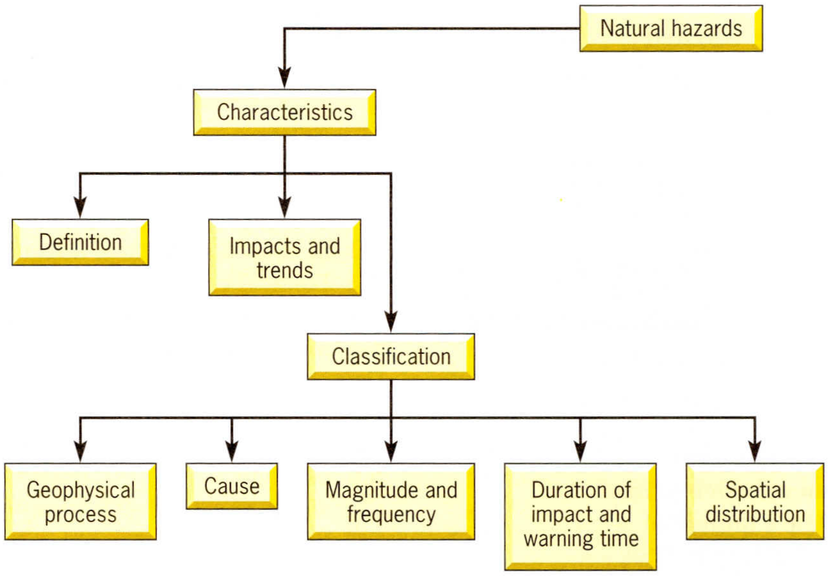
1 Defining and classifying hazards

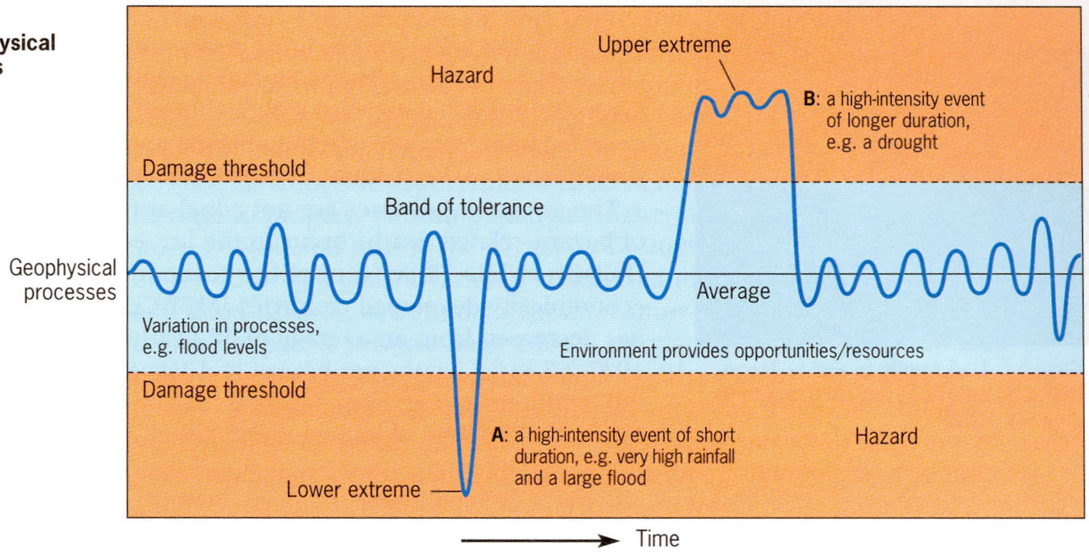


1.1 What is a hazard?

We are all familiar with newspaper and television headlines which show that natural processes can cause loss of life, injury and damage to property. Our awareness of these events is increased by improved global communication systems and the sometimes distressing images that are flashed across our television screens. The **geophysical processes** operating in the lithosphere, hydrosphere, atmosphere and biosphere provide people with opportunities and constraints. The opportunities are the resources we use: for example, forests, fertile crop land on flood plains or near volcanoes, water and energy resources. People have adapted their social and economic systems to what they perceive as the 'normal events' within these geophysical systems.

However, more extreme events can endanger human life and possessions, as shown in Figure 1.1. We can define a natural hazard as a naturally occurring process or event which has the *potential* to cause loss of life or property. The key understanding is that hazards are not just natural events, since without people they are just that – natural processes. It is the interaction of people and the environment that defines a hazard (Fig. 1.2). When studying natural hazards we need to understand both the geophysical processes involved and the human systems.

Figure 1.1 Sensitivity to environmental hazards: geophysical processes and human systems (*After:* Smith, 1996)



Human systems are adapted to 'normal' conditions within the environment (the band of tolerance) but will be disrupted by more extreme natural events. People's use of rivers is a good example, for benefits are gained from living on a fertile flood plain. Flooding is a normal process in the functioning and evolution of river systems, most floods being relatively small and frequent. People have adapted to and benefit from this flood cycle: the soil water store will be refilled, crops irrigated, and houses built above flood levels. However, a large flood may disrupt this human activity, causing loss of crops. A larger area of land will be flooded resulting in loss of life, property and disruption of communications. The flood is now a hazardous event and outside the range of tolerance. Floods are short-term hazardous events (A). A longer-term hazardous event (B) would be a drought, which would cause the river to dry up and disrupt people's activities over a longer period of time.

In 1969 Sheenan and Hewitt defined disaster losses as:
a at least US$1 000 000 damage
b at least 100 people injured
c at least 100 people dead.
One or more of the criteria had to be satisfied for the event to be defined as a disaster. More recently (1990), the Swiss Reinsurance Company defined disaster losses as either or both of:
a at least 20 people killed
b insured damage of at least US$16.2 million.

?

1 Why is it difficult to define a disaster?

2 What are the problems of assigning monetary values to disaster losses?

3 Suggest how different definitions of a disaster will create problems of making comparisons (**a**) of different places at the global scale and (**b**) comparing disasters at different times (temporal comparisons).

Figure 1.2 introduces another term used in hazard studies – that of disaster. A disaster is difficult to define but may be seen as 'the realisation of hazard, although there is no universally agreed definition of the scale on which loss has to occur in order to qualify as a disaster' (Smith, 1996). There are various attempts to put loss boundaries into the definition of a disaster, but these depend upon many variables and the assignment of monetary values becomes quickly dated.

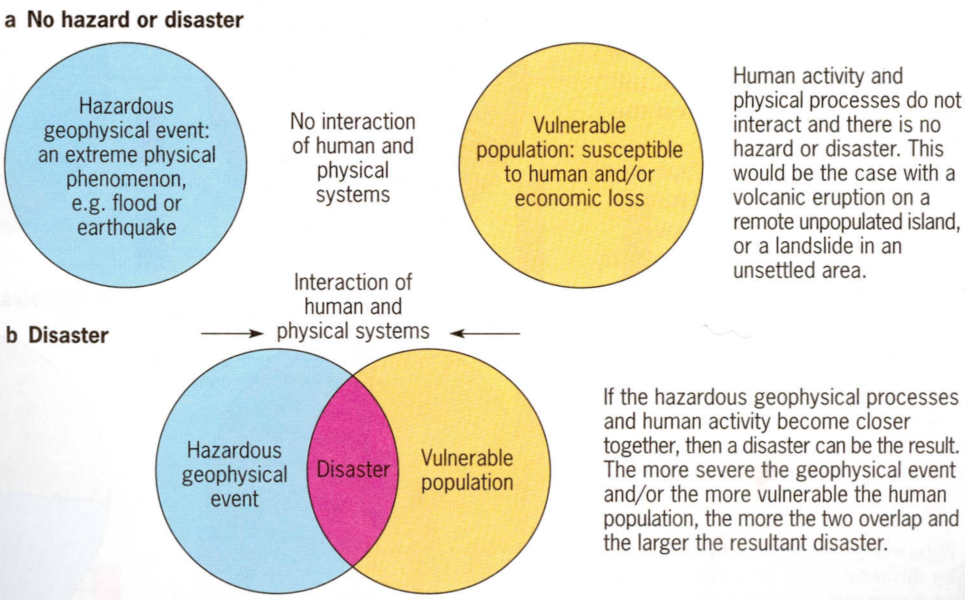
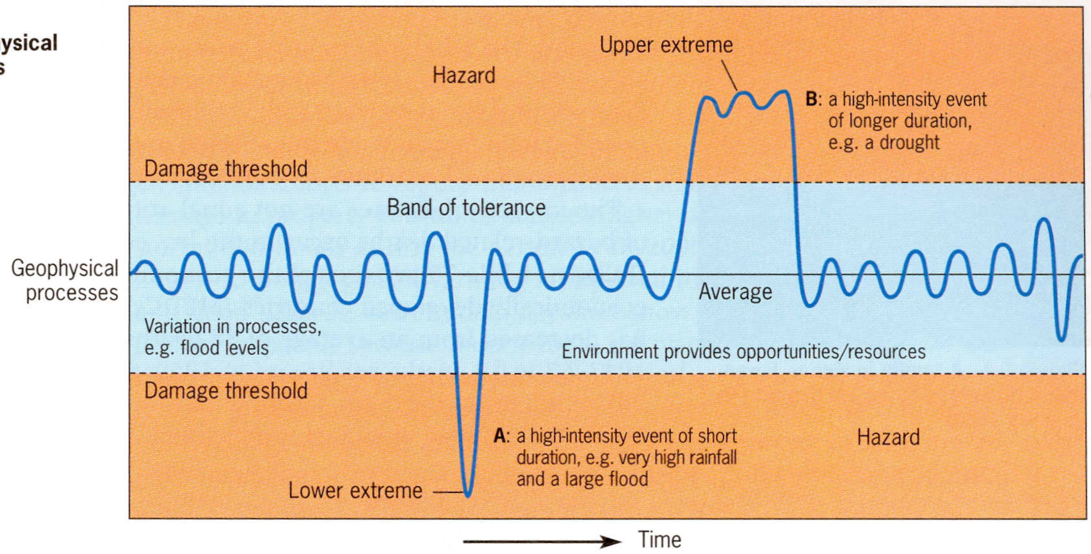


Figure 1.2 The disaster equation: the relationship between hazard, disaster and human vulnerability (*After:* Dregg, 1992)

Figure 1.1 Sensitivity to environmental hazards: geophysical processes and human systems (*After:* Smith, 1996)



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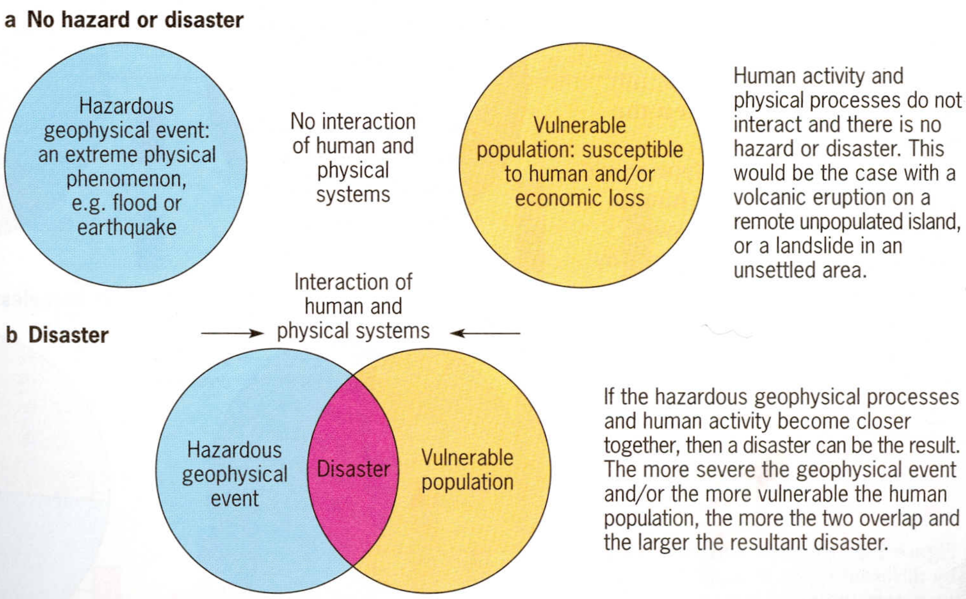

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Figure 1.4 A family in Kobe, Japan, made homeless by an earthquake in January 1995

1.2 Hazard impacts and trends

The impact of a hazard produces direct and indirect losses and disruption (Fig. 1.3) to human systems, including death and injury, property damage, and disruption of social services and communication systems. There is likely to be a need for help from outside the affected area, i.e. other parts of the country or the international community (Fig. 1.4).

The impacts of disaster are not equal at the global scale. Some 90 per cent of hazard-related deaths occur in the less economically developed countries (LEDCs), while 75 per cent of the economic losses occur in the more economically developed countries (MEDCs). In MEDCs the number of deaths has decreased from an average of 38 deaths per hazard during the period 1947–67 to 19 deaths per hazard in 1969–89. In LEDCs, however, the death toll continues to rise from 1000 per hazard during 1947–67 to 2000 during 1969–89. The type of impact is dependent upon the type of hazard (Fig. 1.5).

Losses

Direct
- Deaths
- Physical damage to property/infrastructure
- Injury

Indirect
- Long- and short-term damage to mental health
- Loss of employment
- Loss of ability to earn money as a result of injury
- Disease (e.g. cholera epidemics)
- Disruption of social and economic activity
- Negative multiplier effect (e.g. falling property values, rise in unemployment, less money spent by consumers)

Gains

Direct
- Aid (national and international)
- Reconstruction grants
- Fertile land (e.g. from flood silt or volcanic ash)

Indirect

There is little research into this aspect of hazards

Figure 1.3 Impacts of natural hazards

?

4 Study Figure 1.3.

a Classify the impacts into short-term impacts (few days) and long-term impacts (weeks or years).

b Which impacts can be easily assigned monetary values (i.e. are tangible impacts)?

c What factors will affect (i) how severe the hazard impacts will be on people and (ii) how long the impacts will last?

d When disaster reports in the media say that the costs were put at US$X million, what costs do you think these include?

e Why is it difficult to give monetary values to some impacts?

5 Study Figure 1.5.

a Which hazard types cause the most (i) deaths, (ii) injuries, (iii) homelessness and (iv) affect the most people?

b Which single hazard type would you say caused the most human suffering? Justify your answer.

c What do you think is meant by 'affected' in Figure 1.5(c)? Figure 1.3 may help your answer.

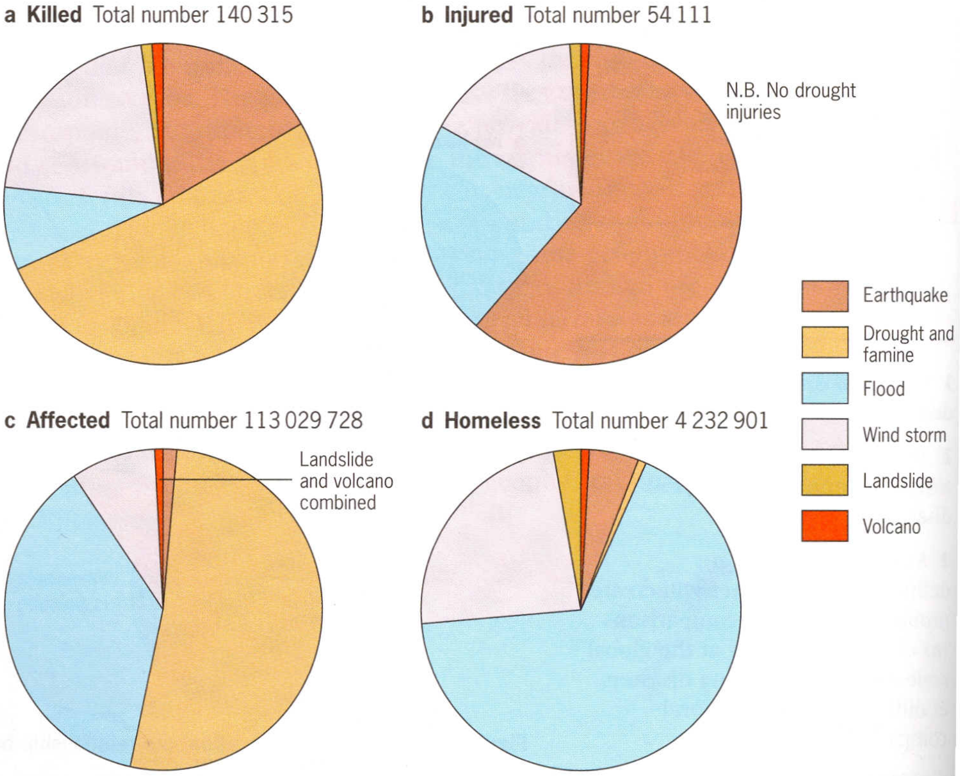


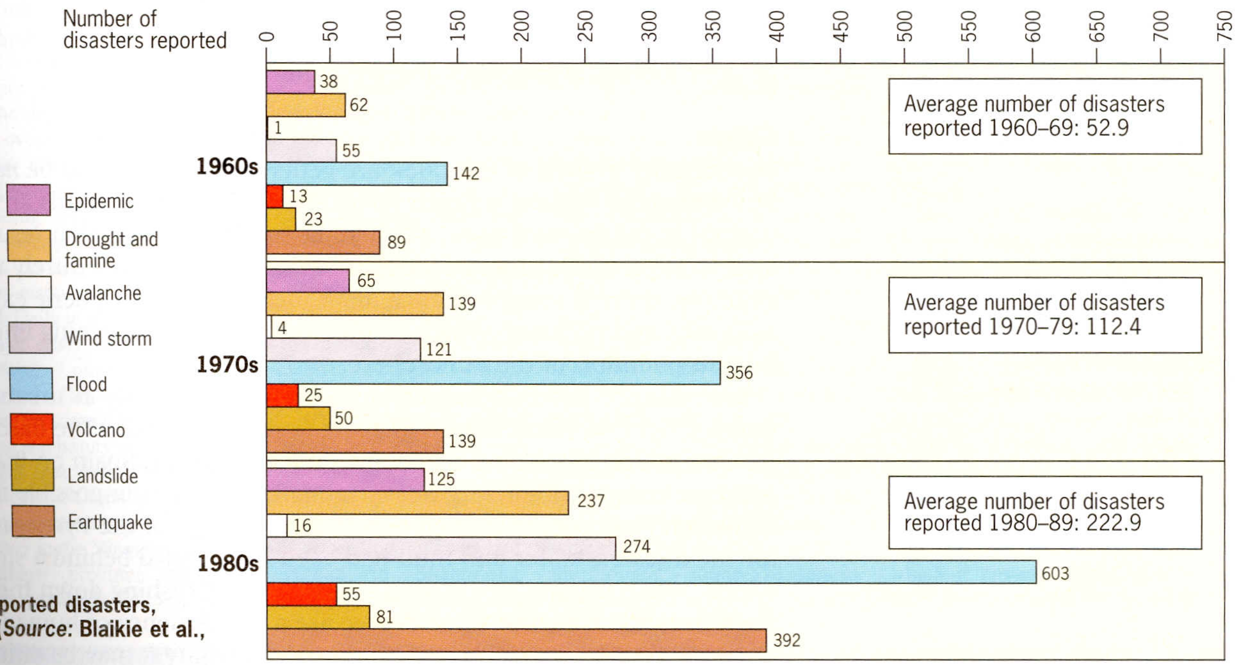
Figure 1.5 People's suffering caused by different types of natural hazard as a percentage of the people affected throughout the world, 1968–92

?

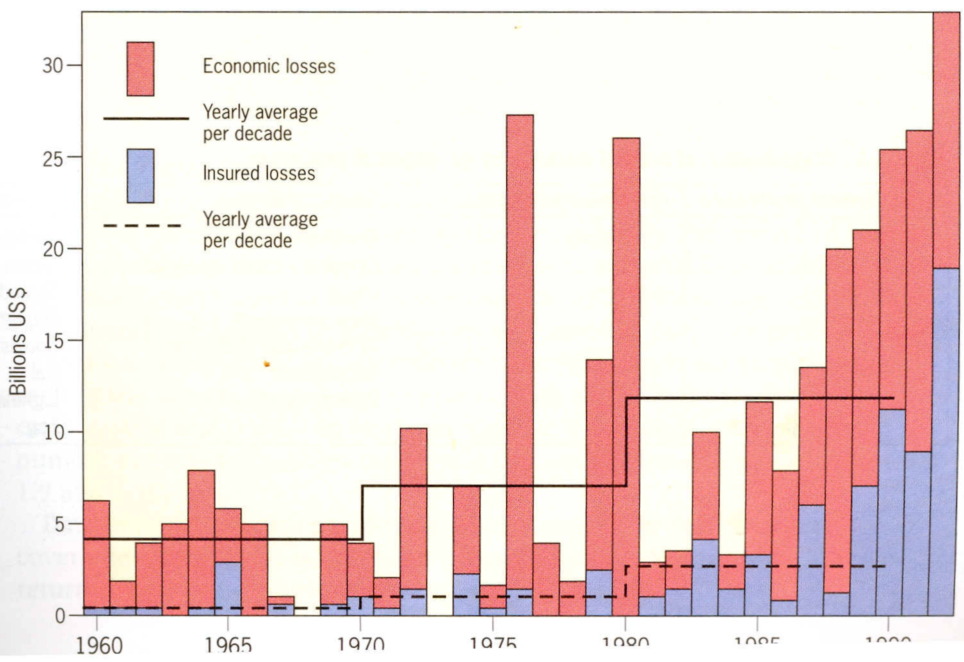
Describe the changes in reported asters shown in Figure 1.6.

Describe the overall trend ɔwn by the graph in Figure 1.7. What are the implications for urance companies?

The number of hazardous events (Fig. 1.6) and the scale of impacts (Fig. 1.7) from natural hazards has shown an upward trend in recent decades. In the 1960s, fewer than 50 million people were affected each year, but by the mid-1990s the number had risen to 250 million each year. The 1990s was the United Nations International Decade for Natural Disasters Reduction (1990–99). Despite the efforts to reduce the impacts of natural hazards, the death toll and damage to property continued to rise. Higher death tolls were recorded from storms and floods during the period 1997–2000 than during 1990–97 (O' Hare, 2001). Although global warming is expected to result in increased atmospheric and flood hazards, current data does not show this as yet. The growth in disaster impact is because more people are placed at risk from potentially hazardous events (remember the definition of a hazard). This is due to many factors, including population growth, land pressure, urbanisation, increased vulnerability, economic growth producing more property to be damaged, and political change which may reduce a government's commitment to internal and international welfare. There is also an increase in the number of reported disasters due to the development of mass media and communications.



gure 1.6 Reported disasters, 960s–1980s (*Source:* Blaikie et al., 994)



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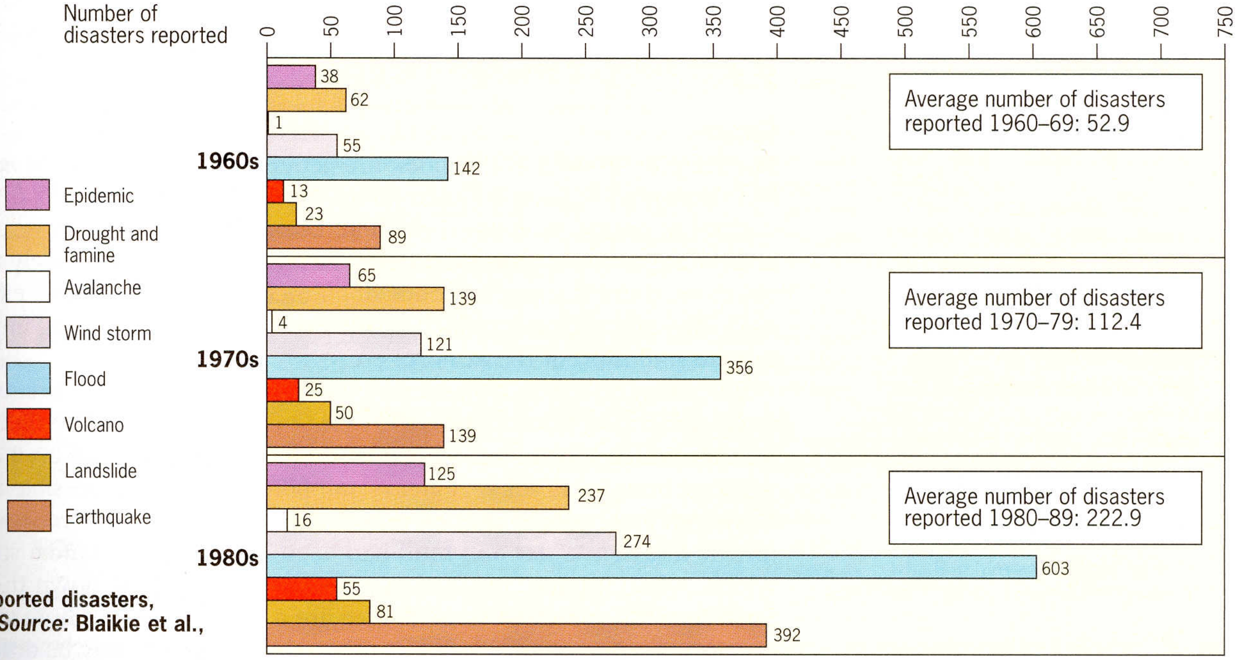

Figure 1.6 Reported disasters, 1960s–1980s (*Source:* Blaikie et al., 1994)

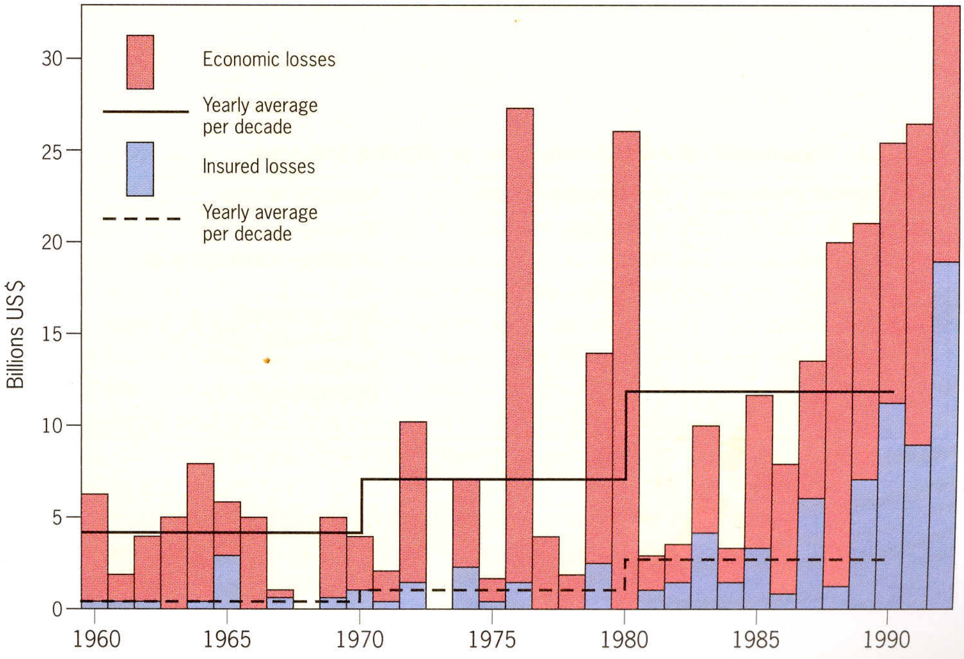

Figure 1.7 The trend in economic and insured losses from disasters recorded 1960–92 (*Source:* Munich Reinsurance Co., in Smith, 1996)

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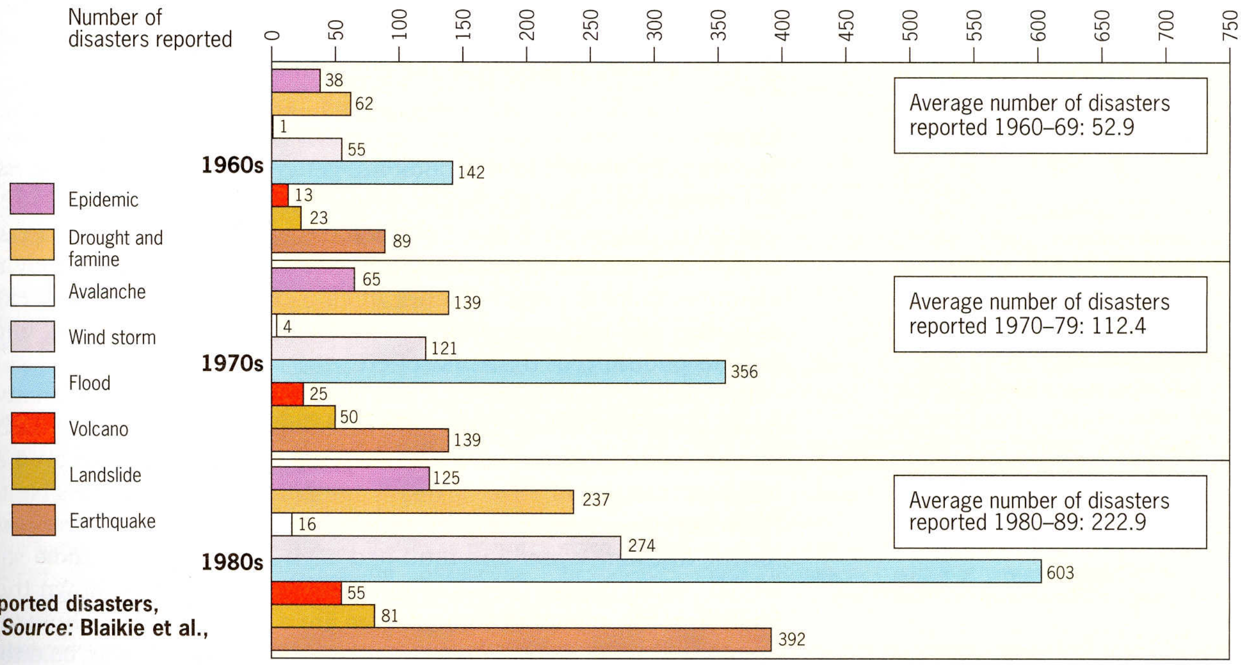

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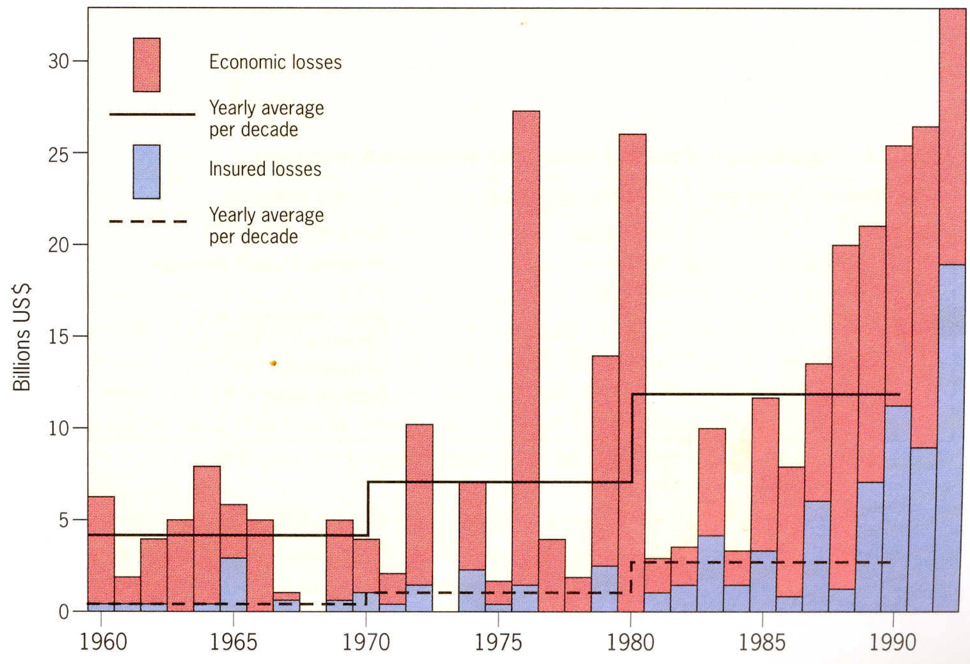

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1.3 Classifying hazards

Hazards are extremely variable in type, magnitude (size), frequency (how often they occur), geographical location and scale of impact. Classification helps us to focus on the key characteristics of different hazards so that they can be more clearly understood. Then the human response to hazards can be managed by governments, planners, hazard managers and insurance companies, as well as by the people directly at risk.

Geophysical processes

Geographers have traditionally classified hazards based upon the geophysical processes which cause the hazard (Table 1.1). This approach is used in the structure of this book, but it is not without its problems. The classification is simple and easily understood but there are problems with accuracy. Many of the geophysical divisions become blurred since some hazardous events produce responses in other geophysical systems. For example, a volcanic eruption can produce landsliding, floods and fires. In some cases more than one geophysical system combine to produce the hazard, as with river flooding and coastal flooding which can result from a combination of atmospheric and geomorphological processes and conditions.

Cause

The hazards studied in this book are generally considered to be *natural hazards*, but there is increasing concern about this term. Some hazards are entirely natural in origin, such as an earthquake or volcanic eruption resulting from large-scale tectonic processes. Other hazards may not be entirely natural. For example, there is some evidence of an increase in atmospheric extremes, such as storms and cyclones, which result from the global warming impacts of human pollution of the atmosphere.

Increasingly, floods are exacerbated by human activity as urban development or deforestation increases runoff processes. The flash-flood disaster which killed over 83 people on a campsite in Spain on 8 August 1996 resulted from localised very heavy rainfall which was impossible to forecast. However, local people blamed recent deforestation of the Pyrenean foothills for the disaster. Water and mud had been impounded behind a small bridge which, when it burst, resulted in a huge torrent rushing down the valley. Such hazards, which to some degree are a consequence of human activity, are termed *quasi-natural hazards*, although in reality it may be difficult to separate them from a more 'natural' hazard.

Table 1.1 Classification of natural hazards by geophysical processes

Geophysical processes	*Tectonic (geological)*	*Geomorphological*	*Atmospheric*	*Biological*
Hazard	Earthquake Volcano Tsunami	Flooding – river Flooding – coast and tidal surge Mass movement, e.g. landslide and avalanche Subsidence Blowing sand	Hurricane/cyclone Storm Tornado Drought Snowstorm/blizzard Hail Lightning Fog	Forest and grassland fire Insect plague Disease, e.g. malaria

Time and water run out for China

Years of neglect and modern life have led to a devastating drought

John Gittings in Hong Kong

China is struggling to cope with a catastrophic drought that has turned the Yellow river into a trickle, dried up deep wells and turned vast areas of farmland into arid waste. After decades in which politics took precedence over the environment, China's prime minister, Zhu Rongji, is trying desperately to reverse the balance.

'Let trees sprout on mountains again, stop growing grain on hilly land and keep your livestock in its pens,' he said recently in a written edict to farmers.

Much of the drought is caused by reckless overuse as China's new consumer society demands more water. Two-thirds of China's cities, including Beijing, face severe water shortages.

'Beijingers do not appreciate their precious resource,' said the Beijing Youth Daily in a survey of the city's water crisis. The three most wasteful outlets, it concluded, are the 'bottled water industry, on-street car-washes and luxury bathing and beauty salons'.

The drought area covers most of north and central China in the interior provinces stretching from the Yellow river to the Yangtze.

The northern province of Hebei, which surrounds Beijing, has been worst hit. About 12 000 square miles of farmland will bear no summer crops and planting has been delayed on another 2000 square miles. In the next province of Henan, rainfall last year was only 14% of the average.

Rainfall in Henan and Anhui provinces last week came too late to save threatened crops and it is no comfort that flood warnings are being issued for the summer in central China. Much of the water is expected to run off uselessly.

Experts have warned that China's plans to develop the less-advanced western provinces could wreak further damage. The western area provides the source waters for the Yellow, Yangtze and other main river systems.

But Mr Zhu, who leads the government task force for western development, is insisting that the ecological balance be maintained.

China is finally having to reckon the hidden cost of massive hydro-electric schemes which have interfered with the natural flow of its great rivers, allowing more water to be diverted and lost by evaporation.

The Yellow river has been worst hit, with no more than a trickle of water flowing in its bed from Henan to Shangdong province on the coast. Authorities at the Xiaolangdi hydro-electric plant are now opening their sluices to let the water run freely and save the farmers' fields downstream.

No solution has yet been found to the well-known paradox that southern China has a surplus of water and has been hit by increasingly severe floods. But long-discussed plans for a south-north water transfer are being revived.

'By the year 2010,' said Wang Xucheng, the water conservancy minister, 'city-dwellers in Beijing are likely to be drinking Yangtze river water.'

And some cities are at least beginning to charge water users according to consumption. Weihai in Shandong has taken the lead, raising the price in the past year from 7p a cubic metre to £3.

Residents have been forced to reuse the same water to wash themselves and flush out their lavatories. There are complaints that some restaurants are cleaning dirty dishes with just rags.

The most tragic stories come, as always, from the countryside. A reporter from the popular newspaper Southern Weekend – which devoted an entire issue to the drought – found villagers in Henan queueing for a trickle that took half an hour to fill a bucket.

Other peasants told of vain attempts to save the lives of thirsty water buffalo by putting damp blankets on their backs.

As fields dry up, desperate farmers are planting their crops in river waterbeds although they know that these may suddenly flood when the weather breaks.

The drought in north China comes after weeks of sandstorms in the early spring, blamed on the loss of tree cover and excessive reclamation of natural waterlands.

Much of the damage was done in the1950s and 1960s when peasants were mobilised in campaigns to increase immediate crop yields without considering the long term.

The new economic reforms of the 1980s, which allowed peasants to shift to profitable cash crops, have also led to overuse as boreholes are drilled even deeper.

Most of the water is wasted – only about 40% is used effectively in dry areas. Some farmers continued to irrigate crops which had no chance of ripening before the water ran dry.

The Yellow river flow is rationed to the provinces through which it passes, according to a fixed formula, but this is ignored.

Figure 1.8 News article: Time and water run out for China (*Source: The Guardian*, 8 June 2000)

?

8 List the physical causes of the drought.

9 How has the economic development added to the severity of this drought?

10 Would you describe this as a natural hazard or a quasi-natural hazard? Explain your answer.

Magnitude and frequency

Magnitude is the size of a natural hazard event or process and represents the amount of geophysical work done by the event, e.g. in the release of built-up energy by an earthquake, or mass movement of material in a landslide. Low-magnitude events tend to have less impact on people than high-magnitude events, and it is difficult to identify precisely at what point the process becomes hazardous. Many geophysical processes have magnitude scales which help us to understand the event and likely impacts, such as the Richter scale for earthquakes, and the Saffir–Simpson scale for hurricanes. *Frequency* is the number of events of a given magnitude that occur over a period of time (Figs 1.9 and 1.10).

Data from monitoring geophysical events tend to be relatively recent and cover a few decades. It is therefore difficult to predict events with long-term return periods, since there may be no record of these.

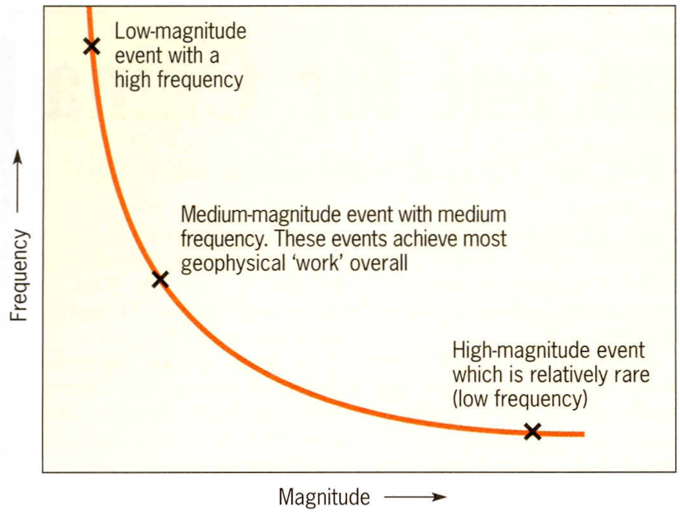

Figure 1.9 The relationship between magnitude and frequency

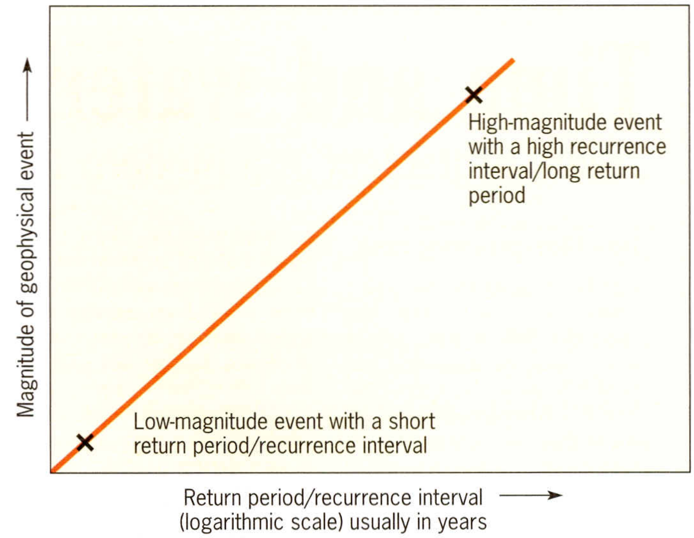

Figure 1.10 The relationship between magnitude and return period

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11 If you were a resident of California, how would you react to a 30 per cent prediction of a high-magnitude earthquake in the next 30 years? Would you take immediate action or not? What type of action could you take? Explain your answer.

12 Study the list of hazards in Table 1.1. Suggest which hazards will show a seasonal occurrence.

Figure 1.11 indicates the approach used to predict hazards by giving statistical probabilities of an event occurring and which thus enables responses to be made. In California, the statistical record of earthquakes extends over the last 150 years. This is a shorter time than the likely recurrence interval for a major earthquake, and so there is an incomplete record of events which makes prediction uncertain. However, in 1988, using past records, seismologists forecast a 30 per cent probability of a magnitude 6.5 earthquake in the Loma Prieta area of the northern San Andreas fault by 2018. In 1989, a magnitude 7.1 event occurred. Using this type of data, decisions can be made about the nature of the threat, the degree of risk and whether protection measures will be taken.

Hazards may follow the pattern of Figure 1.9, or they may be seasonal, or even both. For example, a hurricane may be seasonal in occurrence but the magnitude will vary according to magnitude–frequency relationships. Other events such as lightning and fires are random in occurrence.

Observed results are used to extrapolate the frequency and return period for unobserved events. For example, if a river flood record covers the last 50 years, the largest flood recorded would be represented by **B**. This has a recurrence interval or return period of 50 years, or put it another way, there is 1:50 chance of that magnitude event happening each year. At point **C** there are no records of such a high-magnitude flood, but by extrapolation this would have a recurrence interval of, for example, 100 years, or a 1:100 chance of occurring each year. As more data is collected , the recurrence intervals will be revised.

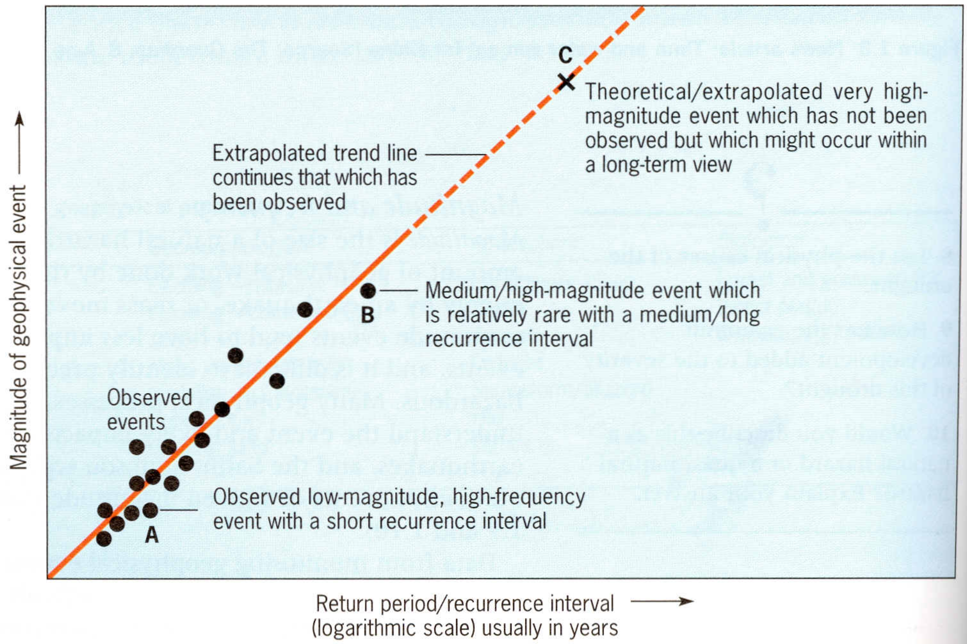

Figure 1.11 Probability of hazardous events

Duration of impact and warning time

Hazards can be classified by the length of time involved in the impact on people and the warning time that is available before the event happens. *Sudden impact hazards*, such as an earthquake (measured in seconds) to tornadoes (minutes) or flash floods (hours), are judged by their casualty and damage figures since warning times are usually short. *Slow onset* or *creeping hazards* may take weeks or months, e.g. drought, some volcanic eruptions, or even years with some types of ground subsidence. These hazards usually affect larger areas and have longer warning times. In reality, however, it is difficult to divide all hazards into these two distinct groups, and there is a continuum of impact duration and forewarning times (Table 1.2).

The duration of the impact needs to be extended when we consider human systems and the post-disaster period (Fig. 1.12).

?

13 Study Figure 1.12.

a Describe the stages of disruption at different phases of the hazard event.

b Suggest how these will differ for an event in an LEDC and an MEDC.

c The pattern shown in Figure 1.12 is for a sudden-impact hazard, e.g. an earthquake. How will the pattern of change vary for a slow-onset hazard such as a drought? Redraw the diagram to explain your answer.

d How will the pattern on the diagram be affected by (i) a very high-magnitude event, (ii) frequent medium- and low-magnitude events?

Spatial distribution

Hazards vary in the spatial characteristics of both their occurrence and their impact (Table 1.3). Some hazards are associated with distinct geographical areas: for example, tropical cyclones occur only in parts of the tropics and earthquakes/volcanoes tend to be associated with tectonic plate boundaries. A further group of hazards are more widespread in occurrence, as with river flooding and mass movements. The scale of impact varies from local to international, with occasional global impacts such as dust and short-term climatic change resulting from large volcanic eruptions.

The impacts of hazards also vary spatially. This is the result of the spatial distribution of the hazardous events and variations in the vulnerability of the population. Data from the OFDA (US Office of Foreign Disaster Assistance) shows that the six most disaster-prone countries in the world are India, the Philippines, Bangladesh, China, Indonesia and Japan. Asia suffers the greatest in terms of deaths due to its large population in vulnerable locations and the relatively large number of people living in poverty (Table 1.4). Africa also suffered great impacts in terms of damage to economies and the number of people affected.

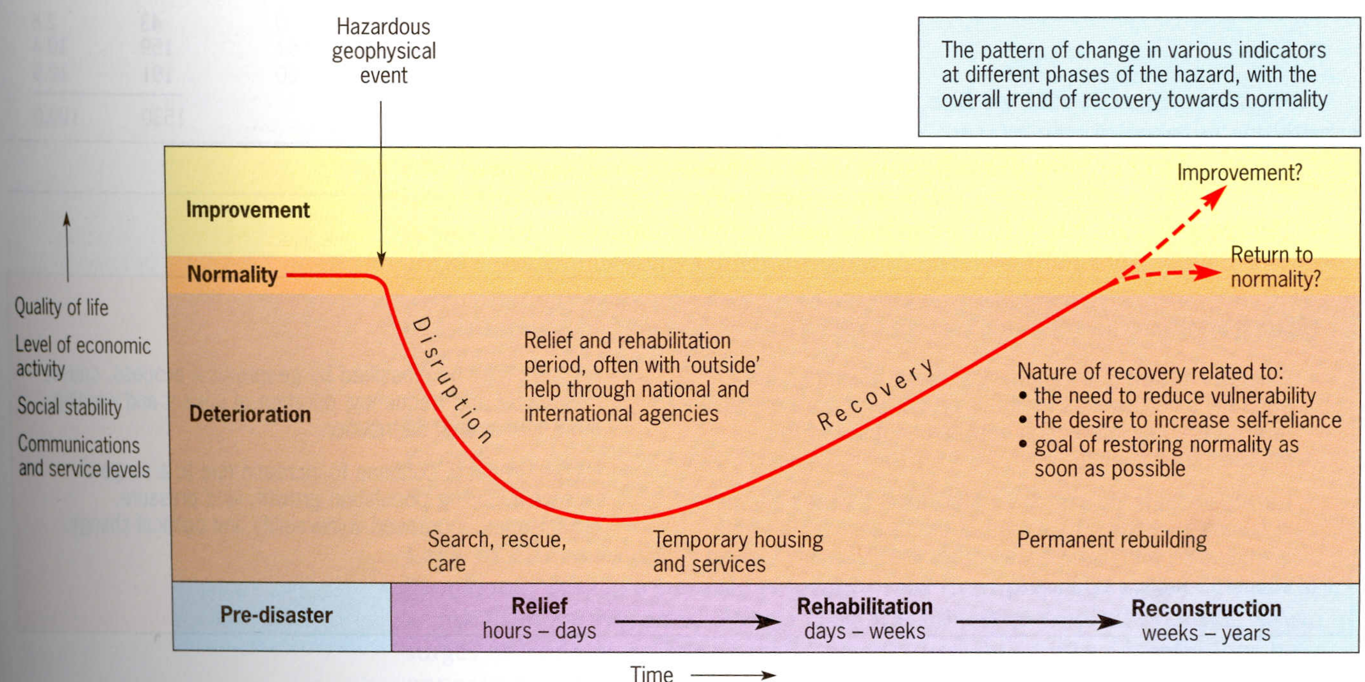

Figure 1.12 Hazard impacts on human systems (*After:* Park, 1991)

Table 1.2 Classification of hazards by duration of impact and length of forewarning (*After:* Alexander, 1993)

Type of hazard	Duration of impact	Length of forewarning
Lightning	Instant	Seconds–hours
Avalanche	Seconds–minutes	Seconds–hours
Earthquake	Seconds–minutes	Minutes–years
Tornado	Seconds–hours	Minutes
Landslide	Seconds–decades	Seconds–years
Intense rainstorm	Minutes	Seconds–hours
Hail	Minutes	Minutes–hours
Tsunami	Minutes–hours	Minutes–hours
Flood	Minutes–days	Minutes–days
Subsidence	Minutes–decades	Seconds–years
Windstorm	Hours	Hours
Frost	Hours	Hours
Hurricane	Hours	Hours
Snowstorm	Hours	Hours
Forest fire	Hours–days	Seconds–days
Insect infestation	Hours–days	Seconds–days
Fog	Hours–days	Minutes–hours
Volcanic eruption	Hours–years	Hours–decades
Coastal erosion	Hours–years	Hours–decades
Drought	Days–months	Days–weeks

Table 1.3 Classification of hazards by spatial occurrence and scale of impact

Hazard	Spatial occurrence	Scale of impact
Earthquake	Global, but distinct zones	Local/regional
Volcano	Global, but distinct zones	Local/regional, but sometimes global
Tsunami	Global, but distinct zones	Local
River flood	Widespread	Local/regional/ international
Coastal flooding	Widespread	Local/regional
Mass movement	Widespread	Local
Subsidence	Widespread	Local
Blowing sand	Restricted to arid/ semi-arid/coastal	Local/regional
Fires	Seasonal drought	Local/regional
Insect plague	Widespread	Local/regional/ international
Disease	Widespread	All scales
Hurricane	Tropics	Local/regional/ international
Storm	Widespread	Local/regional/ international
Drought	Widespread	Regional/international
Snowstorm/blizzard	Temperate/high latitudes	Local/regional
Hail	Temperate/high latitudes	Local
Lightning	Widespread	Local
Fog	Temperate/high latitudes	Local/regional

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14 Present the data in Table 1.4 graphically using a spreadsheet package, or as located proportional symbols on a world map. What are the key features shown by this data?

Table 1.4 Number of significant disasters by continental areas, 1963–1992

	Number of deaths (at least 100)	Significant damage (at least 1% of GNP)	Affected people (at least 1% of population)	Total	Per cent
Asia	378	51	138	567	37.1
Europe	44	8	8	60	3.9
Africa	113	60	181	354	23.1
Caribbean and C. America	32	59	65	156	10.2
North America	41	2	0	43	2.8
South America	77	31	51	159	10.4
Australia and Oceania	101	30	60	191	12.5
				1530	100.0

Source: Adapted from Department of Humanitarian Affairs (1994)

Summary

- A natural hazard is a geophysical event which has the potential to cause loss of life or property. Hazard studies represent a key interaction between people and the physical environment.
- Hazard impacts include direct and indirect losses and gains in human systems. The nature of the losses varies at the global scale with highest loss of life in LEDCs and highest economic losses in MEDCs.
- Hazards may be classified by geophysical process, cause, magnitude and frequency, duration of impact and warning time, and spatial distribution.
- Hazard impacts continue to increase due to a range of factors including population growth, land pressure, urbanisation, increased vulnerability and political change.